Coastal Engineering Technical Note

COMPUTER PROGRAM: GENESIS Version 2

PROGRAM PURPOSE: The GENEralized model for SImulating Shoreline change (GENESIS) is a system of numerical models developed to aid in the evaluation of shore protection design alternatives. These evaluations are accomplished through simulation of the nearshore wave climate and long-term shoreline change.

BACKGROUND INFORMATION: GENESIS calculates shoreline change produced by spatial and temporal differences in longshore sand transport produced by breaking waves. The longshore extent of the modeled reach can range from less than a mile to 50 miles, and simulation time periods can range from 1 month to 10 years. The shoreline evolution portion of the numerical modeling system is based on one-line theory, which assumes that the beach profile shape remains unchanged, allowing shoreline change to be described uniquely in terms of the translation of a single point (for example, Mean High Water shoreline) on the profile. Other features of the modeling system include a wave transformation model to calculate shoaling, refraction, and diffraction; sand bypassing and transmission at shore-perpendicular structures such as groins and jetties; wave transmission at detached breakwaters; and a variety of terminal as well as internal boundary conditions.

The predecessor model to GENESIS (Kraus 1988a,b,c,d) was developed as part of the Nearshore Environment Research Center project conducted in Japan (Horikawa and Hattori 1987). The structure of GENESIS was developed by Hanson (1987) in a joint research effort between the University of Lund, Sweden, and the Coastal Engineering Research Center (CERC), US Army Engineer Waterways Experiment Station (WES). Descriptions of GENESIS Version 1 have been given by Hanson (1987, 1989). The program has been applied at numerous project sites including stretches of coast in Alaska, California, Louisiana, New Jersey, New York, Texas, and outside of the United States as shown in Figure 1 (Hanson and Kraus 1986; Chu et al. 1987; Kraus et al. 1988; Gravens, Scheffner, and Hubertz 1989; Hanson, Kraus, and Nakashima 1989). As a result of these applications, the modeling

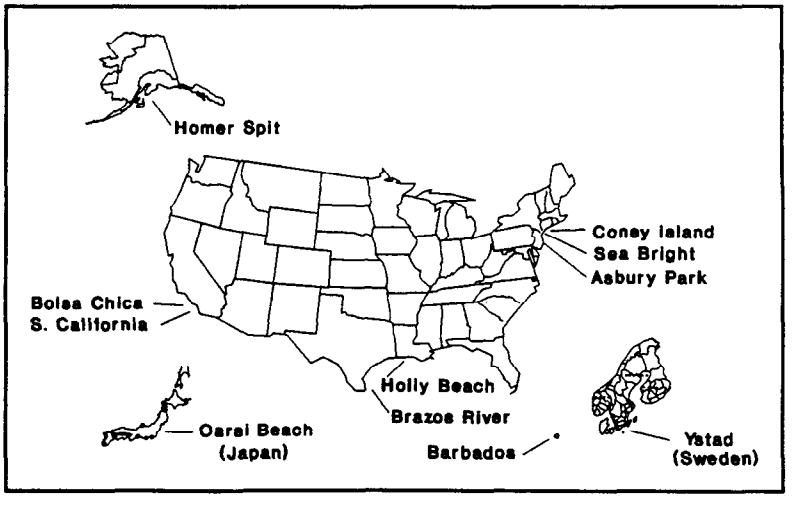

Figure 1. Sites of GENESIS applications

system has undergone substantial testing, revision, and upgrading. These enhancements were of such significance that the present modeling system is designated as GENESIS Version 2. The primary enhancements are:

a. Wave transmission at detached breakwaters.
b. Capability to specify either a diffracting or nondiffracting groin or jetty on a lateral boundary.
c. Inclusion of an arbitrary number of wave sources.
d. Improvement of the user interface.
e. Inclusion of warning and input error messages.

PROGRAM APPLICATION: The GENESIS modeling system is typically applied in the following manner. An area of interest is defined and a Cartesian coordinate system is established with the x-axis aligned parallel to the trend (orientation) of the project shoreline and the y-axis pointing offshore. A system of equi-spaced grid cells which encompass the project area is established, and the project configuration is placed on the grid. The modeling system requires 6 input data files and writes its results to 3 output data files. A summary of the information contained in these files follows.

Initial shoreline positions (relative to the x-axis) at the center of each grid cell are digitized (usually from shoreline maps derived from surveys or aerial photography) and entered into the input file called SHORL. Shoreline positions corresponding to the known shoreline position at the end of the simulation period are specified in the file SHORM. This data allows calculation of a calibration or verification error which conveniently summarizes in a single value the degree of agreement between the calculated and measured shorelines. Offshore wave height, period, and direction of propagation, together with nearshore wave height and direction (if available) are specified in another input file called WAVES. If nearshore wave height and direction data are available (typically obtained from an external wave transformation model such as RCPWAVE; see CETN-I-42) the depths at which the nearshore wave data were saved are specified in the file DEPTH. If a seawall is within the modeled reach, the position of the seawall (relative to the x-axis) is specified in the file SEAWL.

The project specification input file and the principal GENESIS interface is called START; this file contains: (1) model setup, including project name, input length units, number of grid cells, simulation time step, dates at which the simulation is to begin and end, the number and date of desired intermediate shoreline position output, and parameters controlling the magnitude of the longshore sand transport rate; (2) input wave conditions, including wave height and angle multipliers, depth of the offshore wave data input, availability of nearshore wave data, (and the number of shoreline grid cells corresponding to each wave model cell), the time step associated with the input wave data, number of wave conditions per time step, and the date at which the wave data starts; (3) the beach profile, including the effective grain size (for computing the profile shape), average berm height, and depth of closure; (4) nondiffracting and diffracting groins and jetties, including the number of each type, their location and length, depth at the tip of diffracting groins (jetties), representative beach slope near the groins (jetties), and their permeabilities; (5) detached breakwaters, including the

number of breakwaters, the location, depth, and distance from the x-axis of the tips of the breakwaters, and the wave transmission coefficient associated with each breakwater; (6) seawalls within the modeled reach, including their locations; and (7) beach fills to be implemented during the simulation, including the number of beach fills, dates at which the beach-fill operation is to begin and end, location of the beach-fill operations, and the added berm width after adjustment to equilibrium conditions.

Output from the GENESIS modeling system is placed in 3 files called SETUP, OUTPT, and SHORC. The output file, SETUP, is written both to the monitor and to a logical file which can be sent to a printer for a hard copy. SETUP echoes back to the modeler basic information and instructions entered in the input file START.

The file OUTPT holds the most significant output data and calculated results, and includes:

a. Simulation title and initial shoreline position.
b. Calculated shoreline position at the dates or time steps specified by the modeler in the START file.
c. Volume of sand transported alongshore at each grid cell, expressed as a volume per unit time interval, i.e., per annum.
d. Breaking wave height and direction at each grid cell.
e. Longshore sand transport rate at each grid cell for the last time step.
f. Calculated shoreline position at the end of the simulation and the seaward-most and landward-most shoreline positions during the calculation period.
g. Calculated position of the representative contour used for wave refraction calculations.

The output file SHORC also contains the calculated shoreline position at the end of the simulation period. The format of this file is such that it can be renamed to SHORL and used as the initial shoreline in a successive simulation. This feature is very useful if the configuration or number of structures within the model reach changes during the course of the simulation period.

PROGRAM CAPABILITIES AND LIMITATIONS: The GENESIS modeling system contains what is believed to be a reasonable balance between present capabilities to efficiently and accurately calculate coastal sediment transport processes from engineering data and the limitations in both the data and knowledge of sediment transport and beach change. The modeling system and associated methodology have matured through use in numerous types of projects, and are expected to continue to mature with more widespread use. The framework of the system is flexible and will permit enhancements and capabilities to be added in the future as dictated by field office needs. The GENESIS modeling system was designed to describe long-term trends of the beach plan shape in the course of its approach to an equilibrium form. The shoreline change model best calculates shoreline movement in transition from one equilibrium state to another. This change is usually caused by a notable perturbation, for example, by jetties constructed at a harbor or inlet. The modeling system is

not applicable to simulating a randomly fluctuating beach system in which no trend in evolution of the shoreline is evident. In particular, GENESIS is not applicable to calculating shoreline change in the following situations which involve beach change that is not related to coastal structures, boundary conditions, or spatial differences in wave-induced longshore sand transport: beach change inside inlets or in areas dominated by tidal flow; beach change produced by wind-generated currents; storm-induced beach erosion in which cross-shore sediment transport processes are dominant; and scour at structures. In an appropriate application the primary capabilities and limitations of the GENESIS modeling system are listed in Table 1 (Hanson and Kraus 1989).

Table 1
Capabilities and Limitations of GENESIS Version 2

Capabilities
Almost arbitrary numbers and combinations of groins, jetties, detached breakwaters, beach-fills, and seawalls
Compound structures such as T-shaped, Y-shaped, and spur groins
Bypassing of sand around and transmission through groins and jetties
Diffraction at detached breakwaters, jetties, and groins
Coverage of wide spatial extent
Offshore input waves of arbitrary height, period, and direction
Multiple wave trains (as from independent wave generation sources)
Sand transport due to oblique wave incidence and longshore gradient in wave height
Wave transmission through detached breakwaters
Limitations
No wave reflection from structures
No tombolo development (shoreline cannot accrete to a detached breakwater)
Minor restrictions on placement, shape, and orientation of structures
No direct provision for changing tide level
Basic limitations of shoreline change modeling theory

PROGRAM AVAILABILITY: The GENESIS modeling system was originally developed and tested on the CERC VAX 11/750 computer. The modeling system is now available to Corps of Engineers users as an executable file which may be run

on a personal computer (PC). The PC version is available with a companion graphics package which allows visualization of the numerical results. GENESIS will also be incorporated into the Coastal Modeling System (CMS) suite of numerical models accessible on the WES CRAY Y-MP super-computer in FY92. A copy of the PC version of GENESIS may be obtained on floppy disk by contacting Mr. Mark B. Gravens, Coastal Processes Branch, CERC, at (601) 634-3809. Mr. Gravens is responsible for release of the modeling system and is providing consulting support for its use within the Corps of Engineers.

Program documentation is contained in WES Technical Report CERC-89-19 (Hanson and Kraus, 1989). This report provides in-depth discussion of the methodology of model use in the planning context as well as serves as a technical reference for the modeling system. A user's manual and shoreline modeler's workbook is under preparation and will be available in September 1990. These reports can be requested from the Technical Reports Distribution Section at WES (601) 634-2571 or (601) 634-2696.

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